"Heterogeneity informed quantitative micromechanical approach of ductile fracture in 6xxx aluminium alloys"

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Abstract

Ductile fracture results from the nucleation, growth and coalescence of small internal cavities. In aluminium alloys, the void population generally nucleates by the fracture of iron rich intermetallic particles. The objective of this study is to understand and model the effect of microstructure heterogeneities on damage accumulation in three 6xxx series aluminium alloys. The three alloys, i.e. Al 6005A, Al 6061 and Al 6056, exhibit a volume fraction of iron rich particles close to 1%. However, samples of similar yield strengths, owing to appropriate heat treatments, show major differences in the true fracture strain for these three alloys. A cellular automaton model, involving a high number of particles with distribution of position, sizes and void nucleation stress is developed to predict fracture. The model treats local interaction between neighbouring cavities in a simplified way and captures cluster effects on coalescence. The model parameters are extracted from a detailed micros...

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Heterogeneity informed quantitative micromechanical approach of ductile fracture in 6xxx aluminium alloys.

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A cellular automaton model, involving a high number of particles with distribution of position, sizes and void nucleation stress is developed to predict fracture. The model treats local interaction between neighbouring cavities in a simplified way and captures cluster effects on coalescence. The model parameters are extracted from a detailed microstructure analysis. High resolution 3D X-ray synchrotron tomography is used to characterize the size and position distribution of the iron-rich intermetallics and initial cavities in the three alloys. In addition, a statistical study performed on polished fractured tensile samples allows extracting nucleation stresses and the probability of fracture as a function of the size of the intermetallic particle. The model quantitatively predicts all the fracture strain using a single void nucleation stress distribution as a function of particle size with no other fitting parameters. This shows that the key element setting the fracture strain is the effect of particle size distribution and spatial distribution on void nucleation and coalescence.